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(54) Title: ODORS DISCRIMINATION BASED ON SPECTRAL SIGNATURES

(57) Abstract: A method, apparatus and system to compare the odor characters of liquid and gaseous fragrance materials which are based on the comparison of the optical absorption spectrum in the UV to the near IR associated therewith. Samples of a compound having similar odor character have a greater resemblance in their optical absorption spectrum than samples of the same compound with a dissimilar odor character. Accordingly, the odor character of a fragrance material can be classified, authenticated and followed over time by optical absorption measurements.

ODORS DISCRIMINATION BASED ON SPECTRAL SIGNATURES

BACKGROUND OF THE INVENTION

The present invention relates to food and cosmetics processing in general and to a
5 method and apparatus to identify odors of fragrance materials in particular.

The vertebrate olfactory system has long been recognized for its extraordinary sensitivity and selectivity for odors. The theoretical understanding as to why a molecule smells as it does as well as the artificial identification and qualification of odor remain challenging problems.

10 Over the years a number of theories relating odorant quality to molecular properties have been proposed: In 1938, Dyson (Dyson, G.M., *The Scientific Basis of Odor*, Chem. Ind., 57: 647-651 (1938)), suggested that the infrared (IR) resonance which is a measurement of a molecules vibration might be associated with odor.

This idea was popularized by R.H. Wright in the mid 1950's as infrared
15 spectrophotometers became generally available for such spectral measurements which Wright was able to correlate with certain odorants (Wright, R.H., *The Sense of Smell*, CRC Press, Boca Raton, FL (1982)).

In 1946, Linus Pauling indicated (Pauling L., *Molecular architecture and Biological Reactions*, Chem. Eng. News, 24, 1375 (1946); referenced by Ohloff, G., *Scent and Fragrances*, Springer-Verlag, Berlin Heidelberg, (1994)), that a specific odor quality is
20 due to the molecular shape and size of the chemical.

Similarly, in his book John Amoore, (Amoore J., "*Molecular Basis of Odor*" C.C. Thomas, Pub., Springfield (1970)), extended the idea of a "Steric Theory of Odor" originally proposed by R.W. Moncrieff in 1949 (Moncrieff, R.W., "*What is Odor. A New Theory*", Am. Perfumer, 54: 453 (1949)), that stated that air borne chemical molecules are
25 smelled when they fit into certain complimentary receptor sites on the olfactory nervous system.

This "lock and key" approach was an extension from enzyme kinetics. This theory is well suited to the idea that the odorant receptor proteins accept only certain odorants at a
30 specific receptor sites. The receptor is then activated and couples to the G-protein and the signal transduction cascade begins.

Turin in 1996, (Turin, L., *A spectroscopic mechanism for primary olfactory reception*. Chem. Senses, 21, 773-791 (1996)), provided a detailed and plausible

mechanism for the biological transduction of molecular vibrations that, while not accepting the mechanical vibrational spectroscopy theory previously proposed, replaces it with a theory that the receptor proteins act as a "biological spectroscope". What was proposed is a process called "inelastic electron tunneling".

5 According to Turin, an odorous molecule is first docked to its olfactory receptor protein and then may exchange electrons with this receptor by tunneling (an electron transfer between two iso-energetic levels).

 Whether the first step happens depends on the steric properties of the molecule (molecular volume and shape), while the tunneling step depends on the relation between a
10 vibrational energy of the odorant molecule and the energy levels of the receptor.

 It is now obvious that a multiplicity of events occurs in olfaction and that no single analytical technique exists which is sensitive to all relevant odor characterizing parameters of an odorant molecule.

 A Fragrance material means material, which naturally has, or is formulated to have
15 certain useful fragrant characteristics. In most cases fragrance compositions are formulated to have a fragrance generally considered preferably pleasing or at least inoffensive to intended users of the material. Fragrance materials are used for imparting a desired odor to perfumes, raw materials for foodstuff, beverages, tobacco, skin and/or any personal or house hold product including fabric washing powders, washing liquids, fabric softeners and
20 other fabric care products; detergents and household cleaning, scouring and disinfection products; air fresheners, room sprays and pomanders; fine fragrances; soaps, bath and shower gels, shampoos, hair conditioners and other personal cleansing products; cosmetics such as creams, ointments, toilet waters, preshave, aftershave, skin and other lotions, talcum powders, body deodorants and antiperspirants etc., for which an agreeable odor is
25 indispensable or desirable.

 Fragrance materials of such kind are mentioned, for example, in S. Arctander, *Perfume and Flavor Chemicals* (Montclair, N.J., 1969.), in S. Arctander, *Perfume and Flavor Materials of Natural Origin* (Elizabeth, N.J., 1960.) and in "*Flavor and Fragrance Materials*" (Allured Publishing Co. Wheaton, Ill. USA, 1991.).

30 Fragrance compounds are also used in products that would normally have an unattractive or offensive odor to mask this odor and produce an odor that is less unattractive or offensive. Products in this category include fuel odorants.

The (pleasing) fragrant characteristics may be the main function of the product in which the fragrance material has been incorporated, as in the case of a fine fragrance, or may be ancillary to the main function of the product, as e.g. in the case of detergents, cleaning products and skin care products.

5 In either case, odor detection and evaluation plays an important role in the field of quality inspection and authentication of fragrance materials and products, for example, when the freshness of perishable foods being shipped is to be evaluated or when an exact vendor of a perfume has to be verified.

10 Qualification and quantification of odor is needed also in the areas where product differentiation is based on its fragrance. Conventionally, the above-mentioned quality inspections have been carried out by odor organoleptic tests, i.e., by the human sense of smell. The trained human nose remains the preferred choice to differentiate fragrances of difference products.

15 However, such inspections are possible by only those who have a keen sense of smell and taste as well and also are well trained to perform such inspections, such training takes a long time. Further, slight differences in the subjective sensation of smell between trained specialists can lead to rejection of a product. Also the results of the inspections may differ depending upon the physical conditions of the inspector.

20 Thus, because of lack of human objectivity, a need arises for a quality inspection method, through analytical measurement of odors, which can provide objective criteria to identify and differentiate between fragrances according to their odor character.

25 But it has been widely recognized that because of the complexity of the olfaction processes it is difficult to provide such an acceptable method of instrumental analytical measurement of odor, which can also be used to automatically monitor odor based quality inspection processes.

 Most if not all instrumental analytical methods for odor detection and measurement are based on vapor sensing methods to identify the existence or to measure the concentration of a sought analyte in its gaseous state.

30 Gas chromatography has frequently been used in the art for the purpose of measuring individual odors separately. Accordingly, there exist a commercial "Flavors and Fragrances Library" which includes several hundred vapor phase spectra, (http://www.nicolet.com/labsys/products/indust_App.htm).

The gas chromatography, however, is defective in the following points: (1). It requires sampling arrangements for the batch and the results of measurement vary depending upon particular sampling method used; (2). The measurement has to be carried out by a person skilled to some extent; (3). The apparatus useful for such measurement is relatively costly; and (4). It takes a considerable time before the results of measurement are given. Taking the last point (4) into consideration, it can be said that gas chromatography is not suited for an in-situ measurement where it is necessary to provide a real time verification of fragrance materials.

Recently more complex "artificial noses" were introduced. These are transducer's arrays whose collective output signal is in correlation to the existence of a compound having a certain odor, see e.g. in U.S. Patent No. 4,818,348 to Stetter, in U.S. Patent No. 4,884,535 to Ehara, in U.S. Patent No. 5,071,770 to Kolesar, in U.S. Patent No. 5,541,851 to Takaaki and Hirono, in U.S. Patent No. 5,928,609 to Gibson, et al., in T.A. Dickinson, et al. "A chemical-Detecting system based on cross-reactive optical sensor array", Nature, vol.382, 697, 1996, in B.J. Doleman, et al. "Progress in the development of an electronic nose using arrays of chemical sensitive, carbon black-polymer resistors", SPIE vol. 3392, 390, 1998, and most lately in E. J. Staples "Real time characterization of food & beverages using an Electronic Nose with 500 orthogonal sensors and a VaporPrintTM Imaging", <http://www.estcal.com>.

Optical spectroscopic method are relatively simple, quick and reliable, yet they were hardly attempted in replacing organoleptic tests in order to discriminate among fragrance materials or for the verification of the existence of a desired odor in a product.

In U.S. Patent No. 4,384,206, Bjarno uses a correlation between particular absorption bands in the IR spectrum of a fat sample to the "Boar taint" of this sample, to identify articles, which carried this taint.

This method was further extended to the visible part of the spectrum in U.S. Patent No. 4,563,428 to Mortensen.

Both methods in the aforesaid patents, do not address however an unsolved practical problem in which two batches of a fragrance compound which, according to gas chromatographic and mass spectrometric analytical measurements are considered as being "identical", have noticeable differences in their odor character and thus can be specified only by an odor expert. Hence, there exist a widely recognized need for an analytical method which would overcome the disadvantages of presently known organoleptic tests

as described above, and which will allow an automated inspection routine of fragrance quality.

SUMMARY OF THE INVENTION

5 In accordance to the present invention there is provided a method to compare odor character of fragrance materials comprising the steps of: (a) providing a first fragrance material and a second fragrance material, each of the fragrance materials has a characteristic odor, the characteristic odor of the first fragrance material and the characteristic odor of the second fragrance material have a degree of similarity; (b)
10 measuring an optical absorption spectrum of the first fragrance material and an optical absorption spectrum of the second fragrance material and, (c) predicting the degree of similarity between the characteristic odor of the first fragrance material and the characteristic odor of second fragrance material according to a pre-determined criterion which is related to a difference between the optical absorption spectrum of the first
15 fragrance material and the optical absorption spectrum of the second fragrance material.

In accordance to the present invention there is provided a method for on-line detection of a change in an odor character of fluid fragrance material comprising the steps of: (a) providing a fragrance material having a characteristic odor, the fragrance material has a reference absorption spectrum which is associated with the characteristic odor
20 thereof; (b) monitoring on-line an absorption spectrum of the fragrance material and, (c) correlating a detectable change in the measured absorption spectrum of the fragrance material with respect to the reference absorption spectrum of the fragrance material to a change in the characteristic odor of the fragrance material.

In accordance to the present invention there is provided a method for authentication
25 of a fragrance material according to its odor character comprising the steps of: (a) providing a fragrance material having a characteristic odor; (b) measuring an optical absorption spectrum of the fragrance material and, (c) look up of the optical absorption spectrum of the fragrance material in a data base which includes optical absorption spectra of certified fragrance materials to determine an authenticity of the fragrance material.

30 In accordance to the present invention there is provided an odor identifying apparatus comprising of: (a) a tube which confines a fluid fragrance material; the tube transmits light passing perpendicularly to its longitudinal axis, (b) a light source delivering a beam of light in a direction that is about perpendicular to a wall of the tube, the beam of

light is transmitted through the fluid fragrance material in the tube and, (c) a device to detect light at a wavelength of the beam of light, the tube is positioned between the light source and the device to detect light.

In accordance to the present invention there is provided an odor identifying system comprising: (a) an apparatus which measures an absorption spectrum of a fragrance material at a wavelength interval; (b) a data base containing an absorption spectrum of at least one fragrance material at said wavelength interval; (c) an algorithm for comparing absorption spectra of at least two fragrance materials and, (d) a qualitative criterion to differentiate between odor characteristic of fragrance materials according to a result of said comparison.

Other objects and benefits of the invention will become apparent upon reading the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 shows absorption spectra of two samples of 2,3 Hexanedione having similar odor character.

FIG. 2 shows absorption spectra of two samples of 2,3 Hexanedione having dissimilar odor character.

FIG. 3 shows absorption spectra of two samples of 2,3 Pentanedione FCC 98% having similar odor character.

FIG. 4 shows absorption spectra of two samples of 2,3 Pentanedione FCC 98% having dissimilar odor character.

FIG. 5 shows absorption spectra of two samples of Trans-2- Hexanol having similar odor character.

FIG. 6 shows absorption spectra of two samples of Trans-2-Hexanal having similar odor character.

FIG. 7 shows absorption spectra of two samples of 3,4 Hexanedione having similar odor character.

FIG. 8 shows absorption spectra of two samples of 3,4 Hexanedione having dissimilar odor character.

FIG. 9 shows absorption spectra of another two samples of 3,4 Hexanedione having dissimilar odor character.

FIG. 10 shows absorption spectra of two samples of L-Carveol having similar odor character.

FIG. 11 shows a set up for an on line classification of fragrant fluids according to their odor character.

5 FIG. 12 shows a second set up for an on line classification of fragrant fluids according to their odor character.

DETAILED EMBODIMENTS OF THE INVENTION

10 The present embodiments herein are not intended to be exhaustive and to limit in any way the scope of the invention, rather they are used as examples for the clarification of the invention and for enabling of other skilled in the art to utilize its teaching.

 We have found that fragrance compounds which have different odor characteristics and which are indistinguishable within the resolution of chromatographic and mass spectrometric methods can be distinguished by optical absorption measurements in the
15 wavelength range of 0.3-2.5 μm (UV to near IR).

 Taking into account the complexity of olfaction which was previously mentioned, this is by no means an anticipated or a trivial finding and it is used in the present invention to establish a method to specify fragrance compounds in a manner which highly correlates with the determinations of an odor panel.

20 The information shown in Table 1 elucidates the principle of the present invention.

 Liquid samples of various fragrance materials were subjected to the analytical methods of thin layer chromatography, gas chromatography, high pressure liquid chromatography and mass spectrometry gas chromatography.

25 Samples of a certain fragrance compound, which according to all the aforementioned analytical techniques could not be distinguished, within the experimental resolution of the techniques as practiced by the inventors, will be referred hereafter as having "identical composition".

30 For each fragrance compound, samples were prepared in pairs in which each member of the pair represented a different lot of this compound. Members of a single pair with identical composition will be referred hereafter having a "similar" odor character, or a "dissimilar" odor character, as had been determined by an odor panel of 3 experienced persons.

The samples were subjected to a spectroscopic evaluation which was based on the analysis of the absorption spectra of the samples.

A high spectral resolution instrument of type Lambda 900 from Perkin Elmer was used to measure the absorption spectra of the liquid samples in the spectral region between
5 0.2-3 μm .

The Lambda 900 is a dual beam instrument and in the sample chamber one beam was allowed to pass through an empty quartz cell and the other beam passed through a quartz cell of identical dimensions which contained the sample. The spectra were recorded using a computer with dedicated software. Care was taken to clean and dry the cell walls
10 after each sample was measured.

The absorption spectra of a total number of 20 samples of six fragrance compounds were measured and the results are given in FIG. 1-FIG. 10 in the examples in Table 1.

As can be concluded from the figures cited in Table 1; Samples with identical composition and similar odor have substantially the same absorption spectra and samples
15 with identical composition and dissimilar odor have different spectra. These differences were more pronounced in certain spectral regions of the absorption spectra.

E.g. for two spectra having spectral transmittance of $F_1(\lambda)$ and $F_2(\lambda)$ respectively, a simple analytical technique was developed to quantitatively differentiate between these spectra. It includes the definition of two features, which quantify the difference between the
20 two spectra:

$$\text{Feature 1} = \left| \int_{1800}^{2100} (F_1(\lambda) - F_2(\lambda)) d\lambda \right|$$

$$\text{Feature 2} = \int_{1800}^{2100} |F_1(\lambda) - F_2(\lambda)| d\lambda \quad \text{are in nanometers.}$$

25

In Table 1, each example consists of two samples with an identical composition of a certain compound. The samples have either similar or dissimilar odor character and their spectral curves are plotted in the respective figures from which also Feature1 and Feature2
30 are deduced.

As was said before, there is a correlation between odor character similarity and spectral overlap of the curves of the samples in each example.

Feature1 and more specifically Feature2 are sensitive to the odor dissimilarity between the two samples of an example and their numerical value can be used to establish a quantitative criterion, which will classify the samples according to the organoleptic evaluation. E.g. samples of the compound 2,3 Hexanedione for which $\text{Feature1} \leq 5$ have a similar odor character.

When Feature1 and Feature2 are derived from duplicates of the same sample they have marginal values (experimental uncertainties) of about 3 and about 10 respectively.

It is also possible to use more sophisticated algorithms than Feature1 and Feature2 together with a different or multi wavelength range to establish other spectral criteria for odor character similarity. For example: Cross correlation coefficient, wavelet analysis, Fourier analysis and Bayesian decision rules.

Table 1

Summary of the spectral measurements and the odor character of six fragrance materials

Example No.	Compound	Spectral curves	Odor character	Feature1	Feature2
1a	2,3 Hexanedione	Total overlap; FIG 1	Similar	5	53
1b	2,3 Hexanedione	No overlap; FIG. 2	Dissimilar	115	1135
2a	2,3 Pentanedione FCC 98%	Almost total overlap; FIG. 3	Similar	4	43
2b	2,3 Pentanedione FCC 98%	No overlap; FIG. 4	Dissimilar	33	368
3	Trans-2-Hexanol	Almost total overlap; FIG. 5	Similar	6	69
4	Trans -2-Hexanal	Total overlap; FIG. 6	Similar	4.5	21
5a	3,4 Hexanedione	Almost total overlap; FIG. 7	Similar	5	55
5b	3,4 Hexanedione	No overlap; FIG. 8	Dissimilar	26	299
5c	3,4 Hexanedione	No overlap; FIG. 9	Dissimilar	120	1159
6	L-Carveol	Total overlap; FIG. 10	Similar	3	18

A first embodiment of the invention includes the comparison of the rigorous spectra of fragrance compounds which was measured with a spectrometer as described above.

A variation of this measurement in the double beam mode can be done by measuring directly the difference spectrum of two materials. This is done by introducing the
5 two samples into the sample and the reference compartment of the double beam spectrophotometer respectively.

Another embodiment 20 of the present invention is shown in FIGURE 11.

This is a dedicated setup which is based on absorption measurements for real time on-line spectral classification of liquid or gaseous samples according to their odor
10 character.

The setup includes a transparent quartz tube or preferably a quartz hollow body with a rectangular cross section 28, in which a fluid is either flowing or standing still. Alternatively, the tube can be opaque and equipped with two flat transparent windows 27 on opposite side of the tube, which allow the introduction and collection of a flat beam of
15 light 22 sampling the fluid 24 which is confined within the tube.

The beam of light originates from any suitable light source (not shown) in the spectral region of between about 0.3 to about 20 μ m, e.g. a halogen lamp, a deuterium lamp, a tungsten filament lamp, a glow bar, a plurality of light emitting diodes or a tunable laser.

The transmitted light is measured by a detector array 23 which includes a plurality
20 of detector units which are sensitive to light at the wavelengths employed.

In order to monitor the absorption spectrum of the fluid, each detector unit of the array has its light sensitive surface covered by a narrow band-pass optical filter 24 which transmits light only at a selective wavelength. The measurement of the spectrum consists of the simultaneous response of all the detector units of the array, each one at the wavelength
25 transmitted by its respective filter.

Alternatively, white light of the light source can be dispersed before or after its passage through tube 28 by a prism, a grating or a like so that each detector unit of the array 23 is illuminated with a monochromatic light and no need for optical filter 24 exists.

The number of spectral bands as well as their bandwidth is determined according to
30 a bank of spectral signatures of samples that have their absorption spectra correlated to their odor.

In another embodiment 30 shown in FIGURE 12 only one detector 33 is used and the light is focused on its surface by a lens 35.

In this case, replaceable filters 34 at a desired wavelength are introduced before the detector by, e.g. using a rotating wheel 36 which has a plurality of filters mounted on its circumference and which is driven by a step motor (not shown).

In this case a spectrum is obtained by the continuous response of detector 33 as the wheel 36 rotates and filters 34 are swept across the detector's light sensitive face.

The number of filters as well as their bandwidth is determined according to a bank of spectral signatures of samples that have their absorption spectra correlated to their odor.

These signatures are collected by laboratory measurements with a high-resolution spectrophotometer.

The configuration of FIGURES 11, 12 can also be used to determine changes in the odor character of a fluid when it takes place inside the sampled volume. The change in the odor character may occur as part of a chemical process, e.g. oxidation and the odor character change can be detected by the change in the measured spectral signature.

The fluid odor discrimination is noninvasive and has thus advantages over prevailing instruments and methods used to discriminate between fluid odor changes in a dynamic flow situation when these changes are associated with composition changes that could be observed by the aforesaid methods.

In another application of the invention, a measured absorption spectrum of a sample of a fragrance material of an unknown origin is compared to a reference absorption spectrum associated with a certified lot of such a fragrance material, which is stored in a data-base, in order to determine the authenticity of the sample.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A method to compare odor character of fragrance materials comprising the
5 steps of:

- (a) providing a first fragrance material and a second fragrance material, each of said fragrance materials has a characteristic odor, said characteristic odor of said first fragrance material and said characteristic odor of said second fragrance material have a degree of similarity;
- 10 (b) measuring an optical absorption spectrum of said first fragrance material and an optical absorption spectrum of said second fragrance material and,
- (c) predicting said degree of similarity between said characteristic odor of said first fragrance material and said characteristic
15 odor of second fragrance material according to a pre-determined criterion which is related to a difference between said optical absorption spectrum of said first fragrance material and said optical absorption spectrum of said second fragrance material.

20 2. A method as in claim 1 wherein said first fragrance material has a composition that is identical to a composition of said second fragrance material according to a determination of an analytical technique and within an experimental resolution of said analytical technique.

25 3. The method as in claim 2 wherein said analytical technique is selected from the group consisting of gas chromatography and mass spectrometry.

4. The method as in claim 1 wherein said first fragrance material is selected from the group consisting of a liquid sample and a gaseous sample.

30 5. The method as in claim 1 wherein said second fragrance material is selected from the group consisting of a liquid sample and a gaseous sample.

6. The method as in claim 1 wherein said optical absorption spectrum of said first fragrance material is in a wavelength range of between about 0.2 micrometers to about 15 micrometers.

5 7. The method as in claim 1 wherein said optical absorption spectrum of said second fragrance material is in a wavelength range of between about 0.2 micrometers to about 15 micrometers.

8. The method as in claim 1 wherein said degree of similarity between said
10 characteristic odor of said first fragrance material and said characteristic odor of said second fragrance material is determined by an odor expert.

9. The method as in claim 1 wherein said prediction of said degree of similarity between said characteristic odor of said first fragrance material and said characteristic odor
15 of said second fragrance material, depends on an amount of an overlap between said optical absorption spectrum of said first fragrance material and said optical absorption spectrum of said second two fragrance material.

10. The method as in claim 9 wherein said amount of said overlap has a
20 quantitative value.

11. The method as in claim 10 wherein said quantitative value includes a definite integral with respect to wavelength of a difference between said absorption spectrum of said first fragrance material and said absorption values of said second fragrance
25 material.

12. A method for on-line detection of a change in an odor character of a fragrance material comprising the steps of:

- (a) providing a fragrance material having a characteristic
30 odor, said fragrance material has a reference absorption spectrum which is associated with said characteristic odor thereof;
- (b) monitoring on-line an absorption spectrum of said fragrance material and,

(c) correlating a detectable change in said measured absorption spectrum of said fragrance material with respect to said reference absorption spectrum of said fragrance material to a change in said characteristic odor of said fragrance material.

5

13. The method as in claim 12 wherein said fragrance material is selected from the group consisting of a liquid material and a gaseous material.

14. The method as in claim 12 wherein said optical absorption spectrum of said
10 fragrance material is in a wavelength range of between about 0.2 micrometers to about 15 micrometers.

15. A method for authentication of a fragrance material according to its odor character comprising the steps of:

- 15 (a) providing a fragrance material having a characteristic odor;
(b) measuring an optical absorption spectrum of said fragrance material and,
(c) look up of said optical absorption spectrum of said fragrance material in a data base which includes optical absorption spectra of
20 certified fragrance materials to determine an authenticity of said fragrance material.

16. The method as in claim 15 wherein said fragrance material is selected from the group consisting of a liquid material and a gaseous material.

25

17. The method as in claim 15 wherein said optical absorption spectrum of said fragrance material is in a wavelength range of between about 0.2 micrometers to about 15 micrometers.

30 18. An odor identifying apparatus comprising of:

- (a) a tube which confines a fluid fragrance material; said tube transmits light passing perpendicularly to its longitudinal axis,

(b) a light source delivering a beam of light in a direction that is about perpendicular to a wall of said tube, said beam of light is transmitted through said fluid fragrance material in said tube and,

5 (c) a device to detect light at a wavelength of said beam of light, said tube is positioned between said light source and said device to detect light.

19. An odor identifying apparatus as in claim 18 wherein said tube is made of a material selected from the group consisting of metal, plastics, glass and quartz.

10 20. An odor identifying apparatus as in claim 18 wherein said tube is equipped with two windows transparent to said light beam of said light source, said windows diametrically opposite positioned on said wall of said tube.

21. An odor identifying apparatus as in claim 18 wherein said light
15 source is selected from the group consisting of an incandescent lamp, a laser and a light emitting diode.

22. An odor identifying apparatus as in claim 18 wherein said light source
irradiates at a wavelength range of between about 0.2 micrometers to about 15 micrometers.
20

23. An odor identifying apparatus as in claim 18 wherein said device to detect said beam of light is responsive in a wavelength range of between about 0.2 micrometers to about 15 micrometers.

25 24. An odor identifying apparatus as in claim 18 wherein said device to detect light is selected from the group consisting of a single detector and a detector array.

25. An odor identifying apparatus as in claim 24, the apparatus further comprising:

30 (d) a light dispersing element, said light dispersing element positioned between said light source and said device to detect light.

26. An odor identifying apparatus as in claim 24 wherein said device to detect light is a single detector, the apparatus further comprising:
- (d) a set of narrow band optical filters, said filters mounted circumferentially on a rotating wheel which is positioned between
5 said detector and said tube.

27. An odor identifying apparatus as in claim 23 wherein said device to detect light is a detector array which includes a plurality of detector units, each detector unit has a narrow band gap optical filter in front of a light sensitive face of said unit detector, said
10 optical filter projects on said light sensitive face of said detector unit.

28. An odor identifying system comprising:
- (a) an apparatus which measures an absorption spectrum of a fragrance material at a wavelength interval;
- 15 (b) a data base containing an absorption spectrum of at least one fragrance material at said wavelength interval;
- (c) an algorithm for comparing absorption spectra of at least two fragrance materials and,
- (d) at least one quantitative criterion to differentiate between odor characteristic
20 of fragrance materials according to a result of said comparison of absorption spectra.

25

30

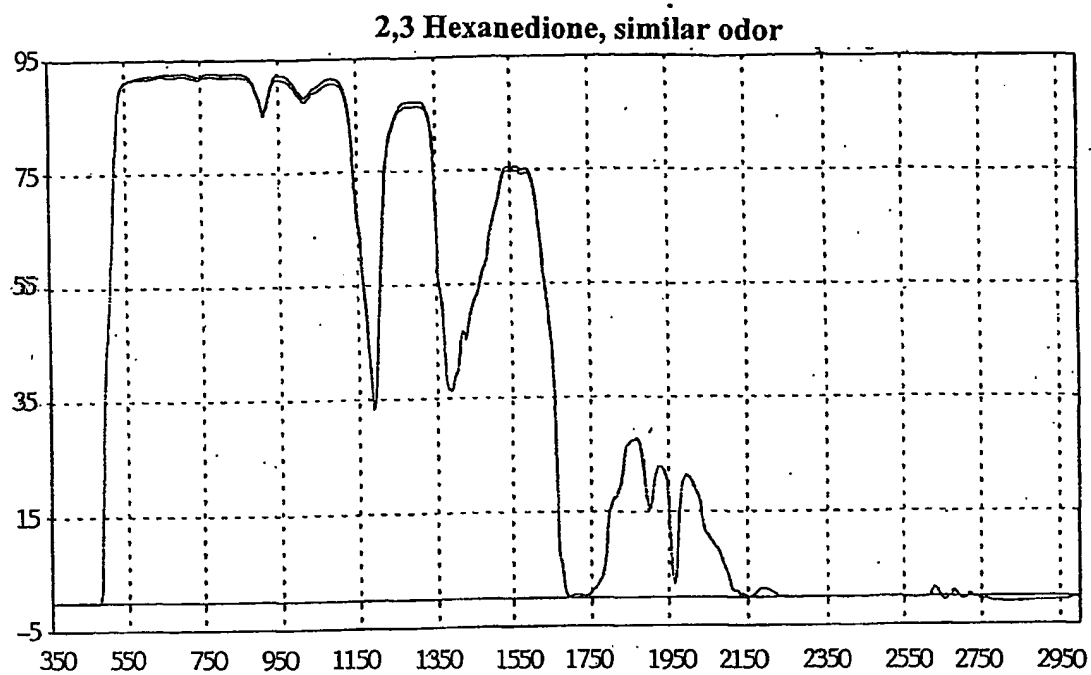


FIG. 1

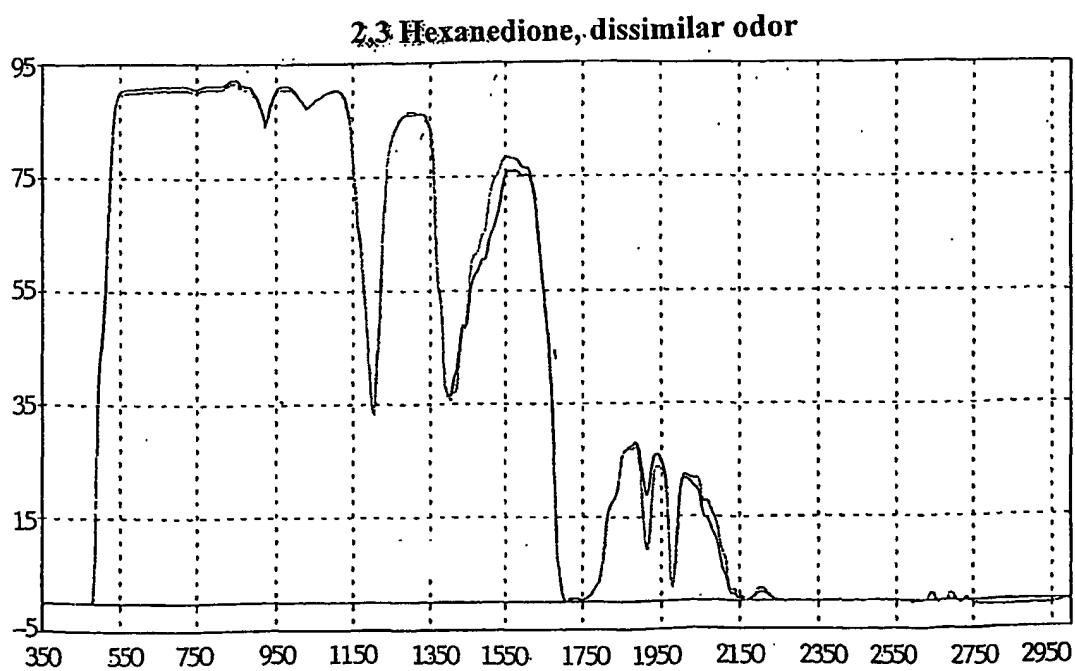
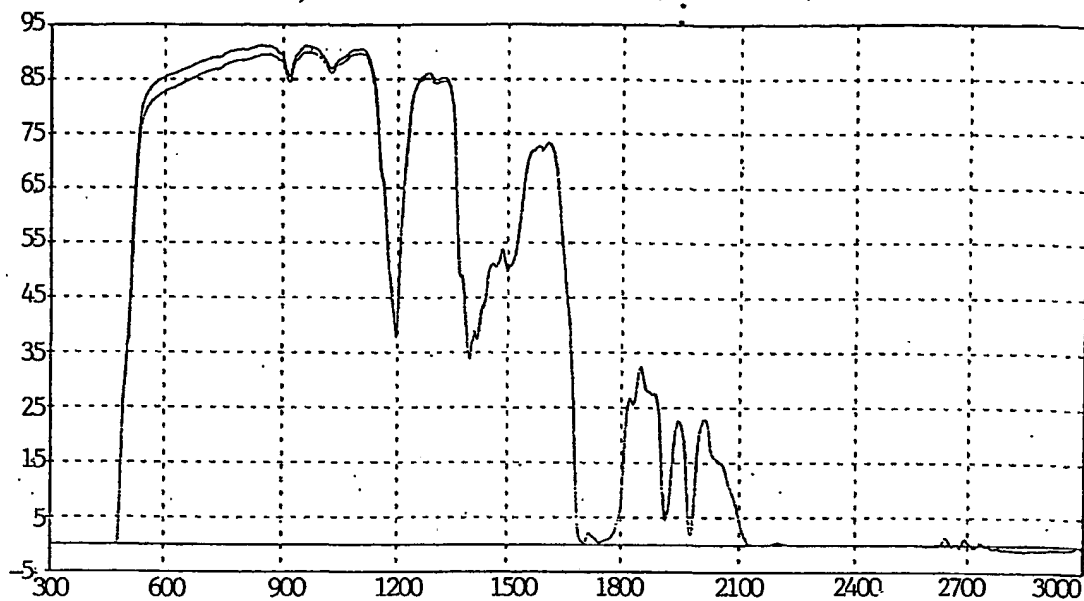
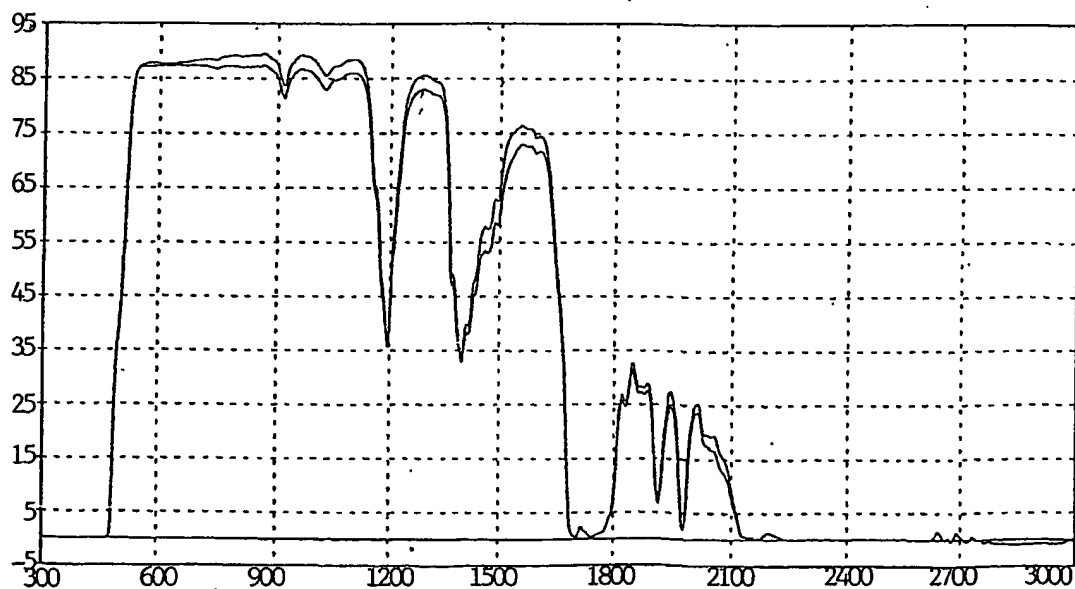
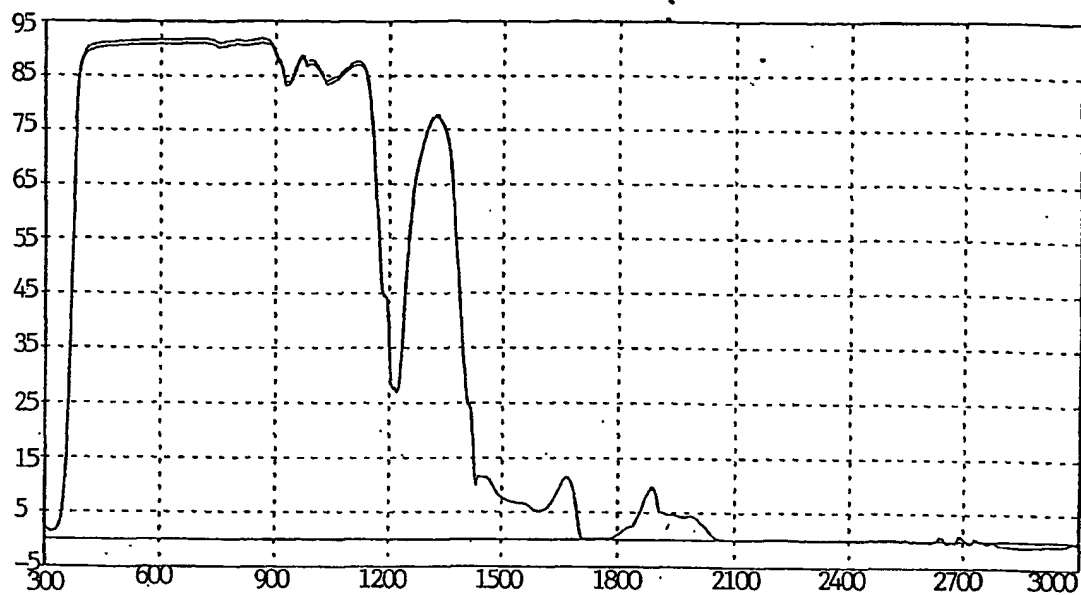
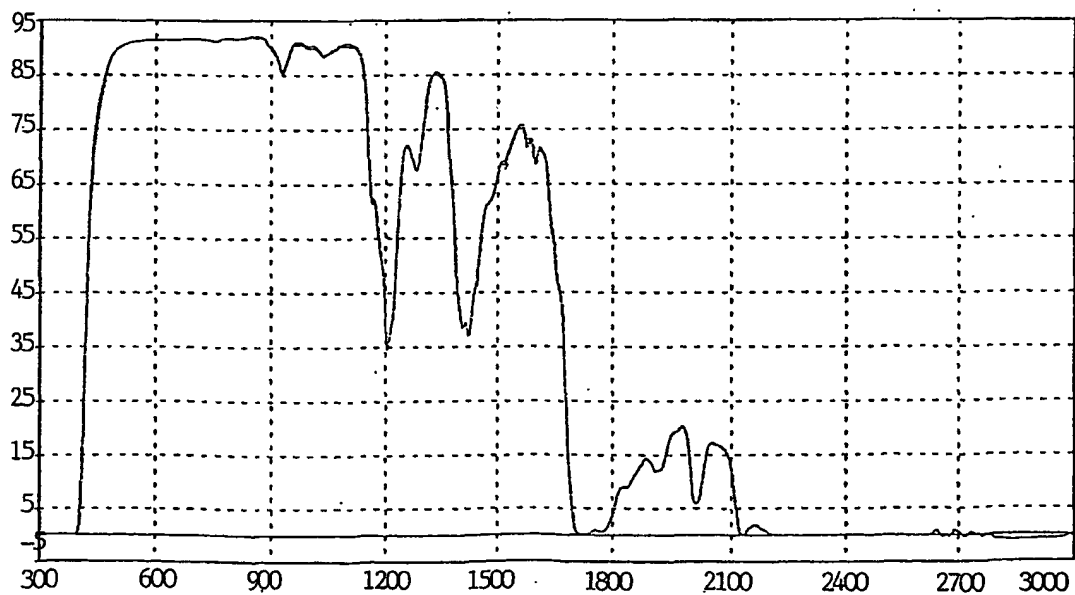


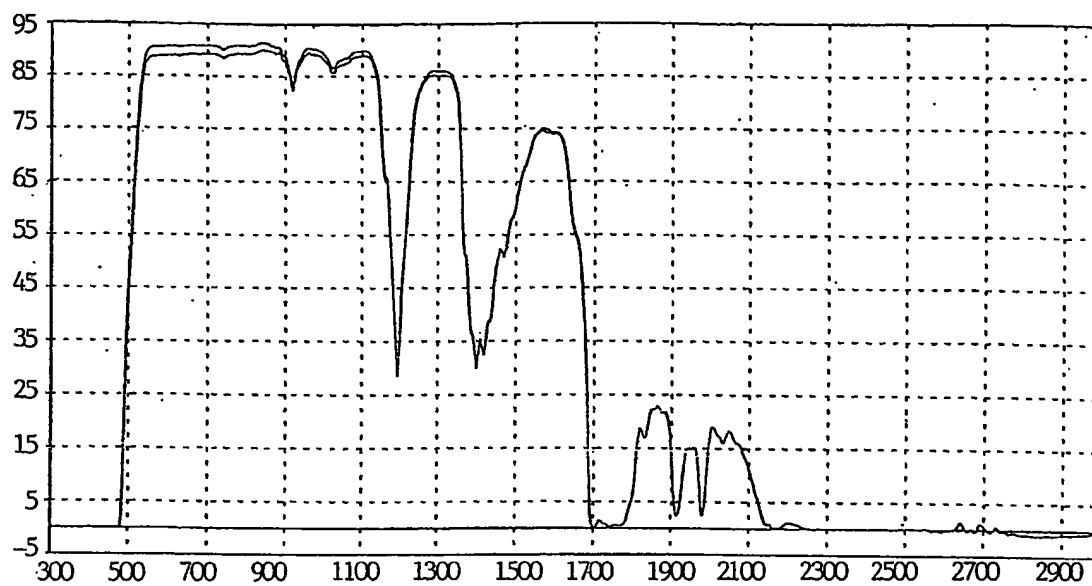
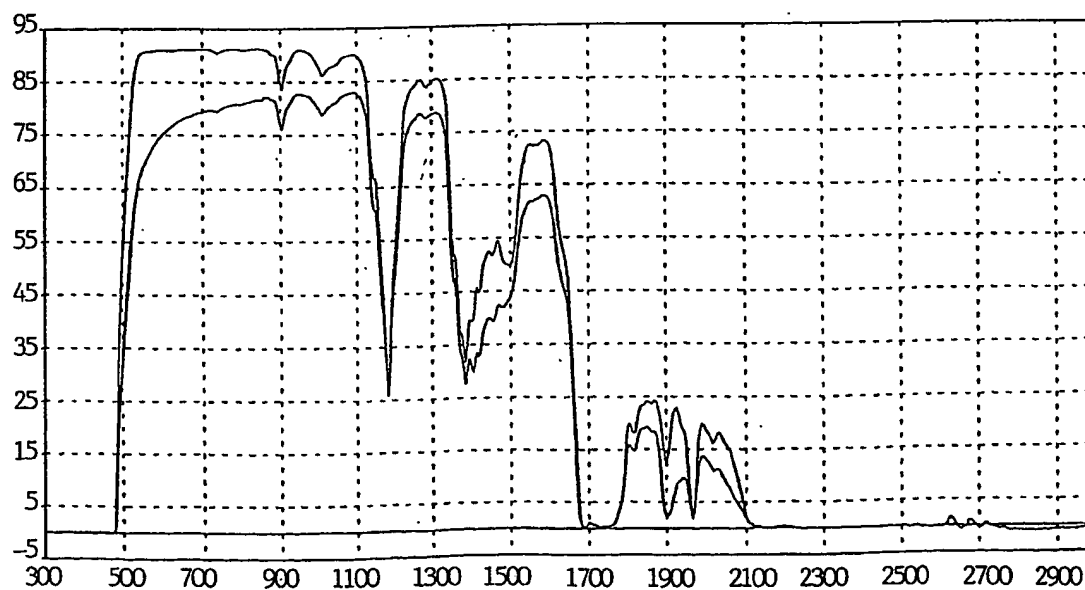
FIG. 2

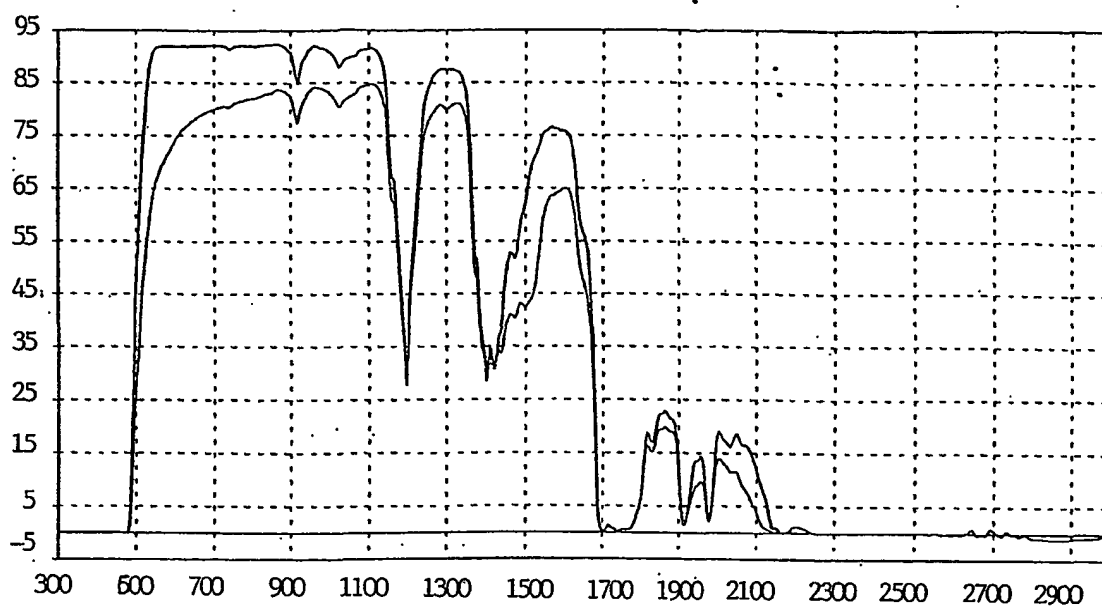
2/6

2,3 Pentanedione FCC 98%, similar odor**FIG. 3****2,3 Pentanedione FCC 98%, dissimilar odor****FIG. 4**

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Trans-2-Hexanol, similar odor**FIG. 5****Trans-2-Hexanol, similar odor****Fig. 6**

3,4 Hexanedione, similar odor**FIG. 7****3,4 Hexanedione, dissimilar odor****FIG. 8**

3,4 Hexanedione, dissimilar odor**FIG. 9****L-Carveol, similar odor****FIG. 10**

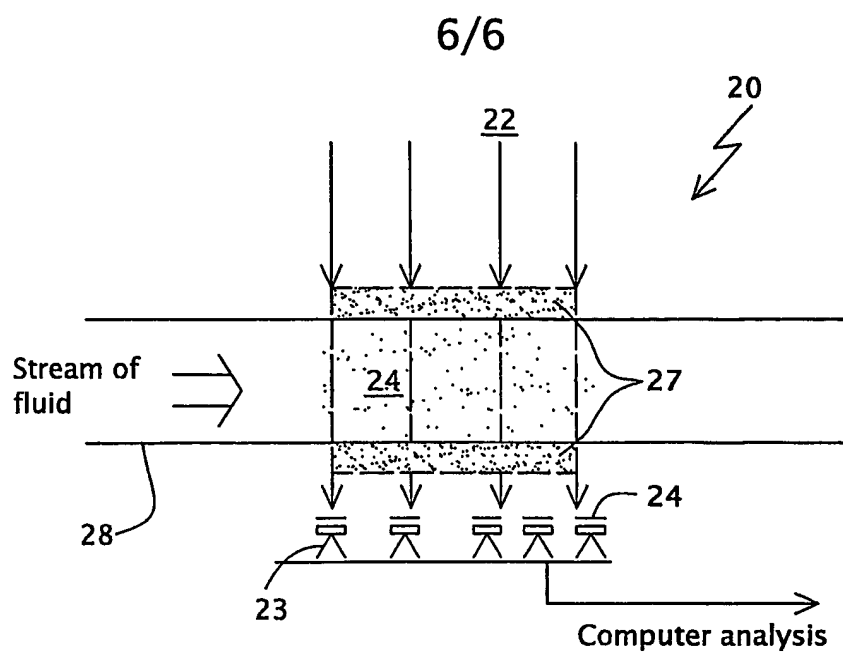


Fig. 11

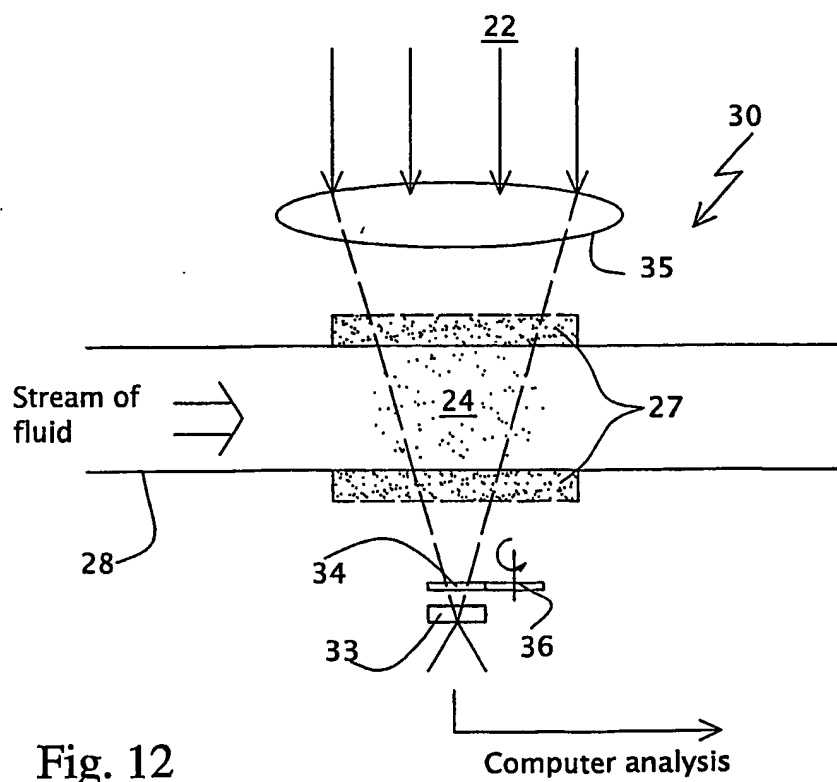


Fig. 12